

Development of Performance-Based Design Methods, Hiroyuki Yamanouchi,
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DEVELOPMENT OF PERFORMANCE-BASED DESIGN METHODS

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I. Topic Description and Policy Issues

The Kobe and Northridge earthquake disasters have pointed out the limitations and deficiency of modern building-structure design codes in the U.S. and Japan. As a result, damage to modern buildings in each city varied greatly, ranging from complete collapse in several instances to virtually no damage whatsoever. This was in spite of the fact that the buildings in question were designed according to the same code and subjected to the same earthquake. Moreover, buildings that suffered little damage to their supporting structural systems were frequently out of service for several weeks or months due to extensive damage to architectural finishes and operating equipment as well as destruction of contents.

Thus far, since both countries use simplified and prescriptive design approaches, structural engineers have been unable to sufficiently answer to multi-performance objectives. Not only design professions but also government officials, business and building owners, representatives of insurance and financial institutions, have now recognized the need for more reliable design methods, especially ones where the damage and disruption due to future destructive earthquakes can be well anticipated and controlled in an economical and reliable manner. Those lessons learned from the damage demonstrated the need to improve design approaches and construction on the basis of performance that engineers and people have expected.

As another point of issues, it should be emphasized that earth scientists are developing refined methods for estimating the seismic threat at a site. However, current design approaches and codes are unable to take advantage of this important new information. Thus, improved and verified engineering design methods and construction procedures are needed on the basis of advanced science and technology.

Tremendous opportunities also exist to develop innovative new structural systems, and to incorporate high performance materials and protective devices, such seismic isolators and energy dissipation devices adapted from high-tech applications, in order to improve the seismic performance of structures.

The advent of low cost, high performance computers, sophisticated simulation software for the simulation of seismic response, and the increased understanding by design engineers of seismic response and the principles of structural dynamics, greatly

facilitates the development and implementation of new design procedures and codes in both the U.S. and Japan.

II. Background

The Building Research Institute of the Japan Ministry of Construction has initiated a three year R&D Program entitled "A New Engineering Framework for Building Structures," since the fiscal year of 1995, in coordination with structure-related communities such as those of structural engineers, contractors, industries, academy and so on. The outline of the Program is shown in Fig. 1.

In the Program, it is hoped that international harmony and consistency should be attained in the conceptual framework on the new engineering system based on performance, paying an attention to the progressing less-bordered world. On this line, Ad-hoc U.S. and Japan study groups held a U.S.-Japan Workshop on Seismic Building Codes, in November of 1995 at the Earthquake Engineering Research Center of the University of California, Berkeley. Further, to follow up the Workshop, most of the participants had again a Meeting in Kobe in January of 1996. The Workshop and Meeting recommended that each side should establish a balanced high level policy/coordination committee to develop a conceptual framework for performance-based design methods and codes under joint cooperation and coordination between the U.S. and Japan.

Also, various professional and academic groups in the U.S. and Japan are beginning to address various aspects of this problem on a joint basis.

III. Proposal

While the economic and social conditions in the U.S. and Japan differ, leading to somewhat different design philosophies and practices, many of the same construction practices, materials, structural systems and architectural features are used in both countries, and similar analytical and design tools are needed. The large scope of work to be undertaken, complexity of the underlying technical and related social problems, and the high cost of obtaining experimental and analytical data to develop and substantiate performance-based design methods clearly points out the advantages of collaborative work between both the countries in this area.

The development of performance-based design methods will be significantly accelerated and improved through collaborative U.S.-Japan research and development on high priority projects of mutual interest and benefit, thorough discussion of fundamental issues related to the theoretical framework underlying performance-based codes, sharing of data and personnel, co-development of innovative structural concepts, and possible joint conduct of "proof of principle" projects incorporating large-scale tests and facilities.

IV. Cooperative Mechanism

Collaboration between the U.S. and Japan will bring together the leading experts in the world on the performance-based design methods of structures. The efforts will provide a fundamentally new framework for the design and evaluation of structures, and significantly contribute to the reduction of future earthquake disasters. Sharing of personnel ideas, concepts, results and findings, including lessons learned from the Northridge and Kobe disasters, will accelerate the development of these improved design methods.

The capabilities of the U.S. and Japan for research and design practice are both highly advanced. Most of the world's experts and resources needed to develop improved seismic design procedures based on performance are located in these two countries. Thus far, however, no collaborative mechanisms exists to coordinate and focus these mutual capabilities on the fundamental technical and social difficulties of establishing reliable performance-based design methods.

To resolve effectively the serious issues, an official mechanism that can support the cooperation is needed under the high level consensus between Japan and the U.S. While the U.S.-Japan Program on Natural Resources (UJNR) is still feasible, the mechanism is the government-to-government basis so that non-governmental institutions and private sectors cannot participate in the system on equal terms. We need a new or modified mechanism to conduct the collaborative activity.

V. Related Issues

VI. Key References

- (1) H. Yamanouchi et al, "Action and Concept on Performance-Based Design and Engineering System in Japan," Proc. of The 28th Joint Meeting, The U.S.-Japan Panel on Wind and Seismic Effects, UJNR, Gaithersburg, U.S.A., May 14-17, 1996.
- (2) "Performance Based Seismic Engineering of Buildings," Structural Engineers Association of California (SEAOC), April 3, 1995.

**Development of Performance Based Structural
Design System in Japan**

Three-year Project from 1995 Fiscal Year

Main Subjects

- Develop Performance Based Structural Design System
(Not only seismic performance but also other performance)
- Convert specific code to performance code in Building Standard Law
- Propose Social System for Performance Based Code

**Pre-study of Performance Based Design from 1992 in cooperation with the
Kozai Club (Non-profit corporation consisting of steel makers)**

**Organization of R/D Project on Performance
Based Design System in Japan**

Technical Committee

Convener: Professor Okada: Tokyo Univ.

Sub Committee 1

Evaluation of Performance

Convener : Professor Akiyama : Tokyo Univ.

Concept of performance of structure
Definition of performance
Measure of performance

Design seismic action, design loads and so on,

Under this sub committee, there are some Working Groups.

Sub Committee 2

Object Performance Level

Convener : Professor Aoki: Tokyo Institute of Tech,

Opinion of clients and users of buildings
Importance category of buildings
Acceptable risk and so on.

Sub Committee 3

Social System

Convener : Dr. Yano: Nikken Sekkei

Construction procedures
Design review
Qualification of engineers
Role of building officials and so on.

An International Committee (under consideration)

Fig. 1 R/D Project for Performance Based Design